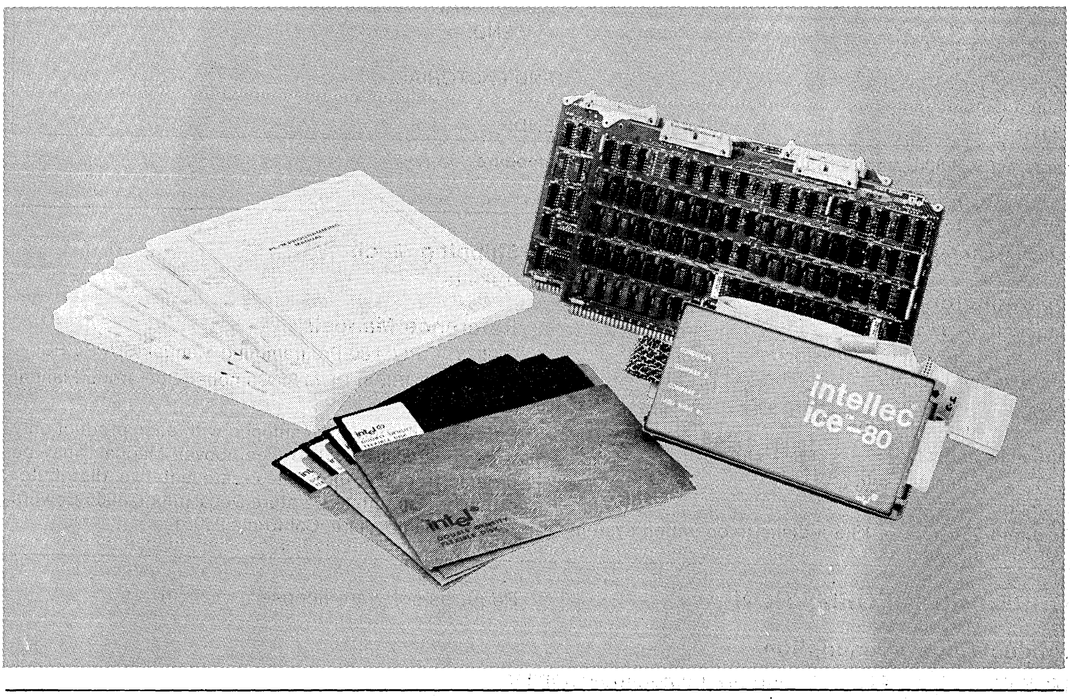
intel®

ICE-80™
8080 IN-CIRCUIT EMULATOR

- **Connects Intellec® System to User Configured System Via an External Cable and 40-pin Plug, Replacing the User System 8080**
- **Allows Real-Time (2 MHz) Emulation of User System 8080**
- **Shares Intellec® RAM, ROM, and PROM Memory and Intellec® I/O Facilities with User System**
- **Checks for Up to Three Hardware and Four Software Break Conditions**
- **Offers Full Symbolic Debugging Capabilities**
- **Eliminates Need for Extraneous Debugging Tools Residing in User System**
- **Provides Address, Data, and 8080 Status Information on Last 44 Machine Cycles Emulated**
- **Provides Capability to Examine and Alter CPU Registers, Main Memory, Pin, and Flag Values**
- **Integrates Hardware and Software Development Efforts**
- **Available in Diskette or Paper Tape Versions**

The Intellec ICE-80 8080 In-Circuit Emulator is an Intellec resident module designed to interface with any user configured 8080 system. With ICE-80 as a replacement for a prototype system 8080, the designer may emulate the system's 8080 in real time, single step the system's program, and substitute Intellec memory and I/O for user system equivalents. Powerful Intellec debug functions are extended into the user system. For the first time the designer may examine and modify his system with symbolic references instead of absolute values.



FUNCTIONAL DESCRIPTION

Integrated Hardware/Software Development

Use of the ICE-80 module enables the system integration phase, which can be so costly and frustrating when attempting to mesh completed hardware and software products, to become a convenient two-way debug tool when begun early in the design cycle. The user prototype need consist of no more than an 8080 CPU socket and a user bus to begin integration of software and hardware development efforts. With the ICE-80 mapping capabilities, system resources may be accessed for missing prototype hardware. Hardware designs may be tested using system software to drive the final product. A functional block diagram of the ICE-80 module is shown in Figure 1.

Symbolic Debugging Capability

ICE-80 provides for user-defined symbolic references to program memory addresses and data. Symbols may be substituted for numeric values in any of the ICE-80 commands. The user is thus relieved from looking up addresses of variables or program subroutines.

Symbol Table — The user symbol table generated along with the object file during a PL/M-80 compilation or a MAC80 or resident assembly, is loaded to memory along with the user program to be emulated. The user may add to this symbol table any additional symbolic values for memory addresses, constants, or variables found useful during system debugging. By referring to symbolic memory addresses, the user may be assured of examining, changing, or breaking at the intended location.

Symbolic Reference — ICE-80 provides symbolic definition of all 8080 registers, flags, and selected pins. The following symbolic references are also provided for user convenience: TIMER, a 16-bit register containing the number of ϕ_2 clock pulses elapsed during emulation; ADDRESS, the address of the last instruction emulated; INTERRUPTENABLED, the user 8080 interrupt mechanism status; and UPPERLIMIT, the highest RAM address occupied by user memory.

Debug Capability Inside User System

ICE-80 provides for user debugging of full prototype or production systems without introducing extraneous hardware or software test tools. ICE-80 connects to the user system through the socket provided for the user 8080 in the user system (See Figure 2). Intellec memory is used for the execution of the ICE-80 software, while I/O provides the user with the ability to communicate with ICE-80 and receive information on the generation of the user system. A sample ICE-80 debug session is shown in Figure 3.

I/O Mapping and Memory

Memory and I/O for the user system may be resident in the user system or "borrowed" from the Intellec system through ICE-80's mapping capability.

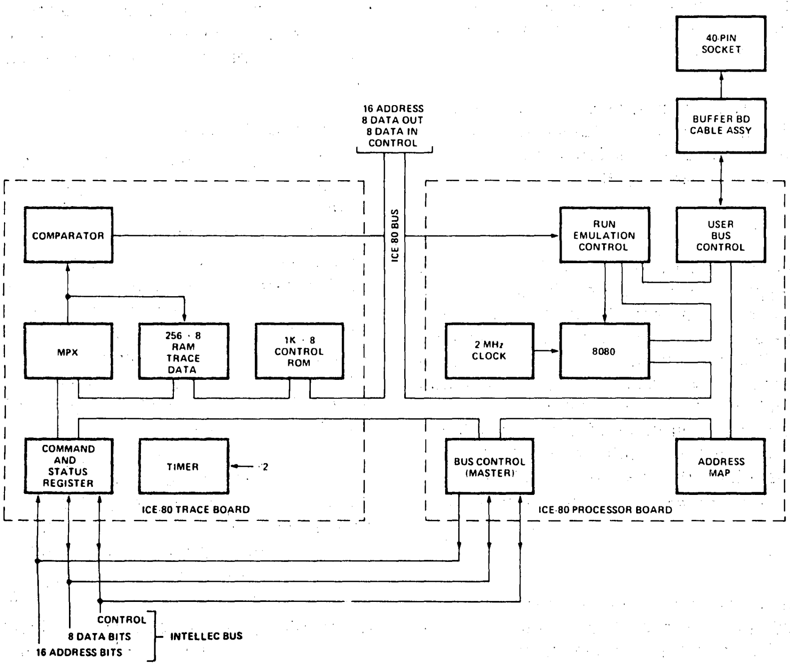


Figure 1. Functional Block Diagram of ICE-80 Module

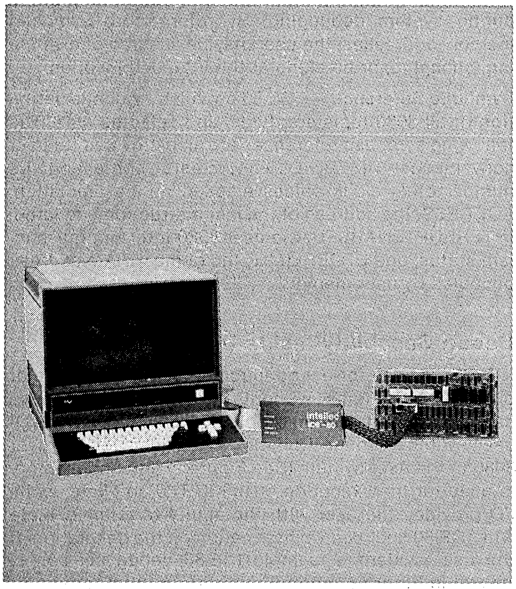


Figure 2. ICE-80 Module Installed in User System

Memory Blocking — ICE-80 separates user memory into 16 4K blocks. User I/O is divided into 16 16-port blocks. Each block of memory or I/O may be defined independently. The user may assign system equivalents to take the place of devices not yet designed for the user system during prototyping. In addition, memory or I/O may be accessed in place of user system devices during prototype or production checkout.

Error Messages — The user may also designate a block of memory or I/O as nonexistent. ICE-80 issues error messages when memory or I/O designated as nonexisting is accessed by the user program.

Real-Time Trace

ICE-80 captures valuable trace information while the user is executing programs in real time. The 8080 status, the user memory or port addressed, and the data read or written (snap data), is stored for the last 44 machine cycles executed. This provides ample data for determining how the user system was reacting prior to emulation break. It is available whether the break was user initiated or the result of an error condition. For detailed information on the actions of CPU registers, flags, or other system operations, the user may operate in single or multiple step sequences tailored to system debug needs.

Hardware

The heart of the ICE-80 is a microcomputer system utilizing Intel's 8080 microprocessor as its nucleus. This system communicates with the Intellec host processor via I/O commands. Host processor commands and ICE-80 status are interchanged through registers on the ICE-80 trace board. ICE-80 and the system also communicate through a control block resident in the Intellec main memory, which contains detailed configuration and status information transmitted at an emulation break. ICE-80 hardware consists of two PC boards — the processor and trace boards residing in the Intellec chassis — and a 6-foot cable interfacing to the user system. The trace and processor boards communicate with the system on the bus, and also with each other on a separate ICE-80 bus. ICE-80 connects to the user system through a cable that plugs directly into the socket provided for the user's 8080.

Trace Board

The trace board talks to the system as a peripheral device. It receives commands to ICE-80 and returns ICE-80 responses. While ICE-80 is executing the user program, the trace board collects data for each machine cycle emulated (snap data). The information is continuously stored in high-speed bipolar memory.

Breakpoint — The trace board also contains two 24-bit hardware breakpoint registers which can be loaded by the user. While in emulation mode, a hardware comparitor is constantly monitoring address and status lines for a match to terminate an emulation. A user probe is also available for attachment to any user signal. When this signal goes true a break condition is recognized.

Interrogation — The trace board signals the processor board when a command to ICE-80 or break condition has been detected. The ICE-80 CPU then sends data stored on the trace board to the control block in memory. Snap data, along with information on 8080 registers and pin status and the reason for the emulation break, are then available for access during interrogation mode. Error conditions, if present, are transmitted and automatically displayed for the user.

Processor Board

An 8080 CPU resides on the processor board. During emulation it executes instructions from the user's program. At all other times it executes instructions from the control program in the trace module's ROM.

Timing — The processor board contains an internal clock generator to provide clocks to the user emulation CPU at 2 MHz. The CPU can alternately be driven by a clock derived from user system signal lines. The clock source is selected by a jumper option on the board. A timer on the trace board counts the ϕ_2 clock pulses during emulation and can provide the user with the exact timing of the emulation.

On/Off Control — The processor board turns on an emulation when ICE-80 has received a run command from the system. It terminates emulation when a break condition is detected on the trace board, or the user's program attempts to access memory or I/O ports designated as nonexistent in the user system, or the user 8080 is inactive for a quarter of a second.

Status Storage — The address map located on the processor board stores the assigned location of each user memory or I/O block. During emulation the processor board determines whether to send/receive information

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ISIS 8080 MACROASSEMBLER, V1.0              PAGE 1

                ;USER PROGRAM TO OUTPUT A SERIES OF
                ;CHARACTERS TO SDK-80 CONSOLE DEVICE
                ;
1320                    ORG   1320H
01E3            CO      EQU   1E3H   ;SDK-80 CONSOLE OUT DRIVER
                ;
1320 0601       START:  MVI   B,1    ;SET UP B VALUE
1322 3A3613             LDA   DAT1   ;LOAD A WITH DAT1 VALUE
135 4F          LOOP:   MDV   C,A
1326 CDE301             CALL  CO     ;SEND C VALUE TO CONSOLE
1329 79                 MOV   A,C    ;RESTORE A
132A 93                 SBB   B      ;SUBTRACT B FROM A
132B 323713             STA   RSLT   ;STORE RESULT IN RSLT
132E FE40               CPI   40H    ;LAST VALUE TO PRINT
1330 C22513             JNZ   LOOP   ;LOOP AGAIN IF A>40H
1333 C32013             JMP   START  ;ELSE RESTART WHOLE PROCEDURE
                ;
1336 5A         DAT1:   DB    5AH
1337            RSLT:   DS    1
0000                    END

ISIS, V1.0      INITIAL ICE-80 SESSION
-ICE80          (Note: The SDK-80 Monitor has already been used to initialize the SDK-80 Board)
ISIS ICE-80, V1.0
(1) **XFORM MEMORY 0 TO 1 U
    *XFORM IO 0FH U
(2) *LOAD PROG. HEX
    ERR=067
    STAT=11H TYPE=06H CMND=07H ADDR=1320H GOOD=06H BAD=04H
    *CHANGE MEMORY 1321H=FFH
    ERR=067
    STAT=11H TYPE=06H CMND=07H ADDR=1321H GOOD=FFH BAD=FDH
    *LOAD PROG. HEX
(3) *GO FROM START UNTIL RSLT WRITTEN
    EMULATION BEGUN
(4) ERR=067
    STAT=11H TYPE=07H CMND=02H
(5) *DISPLAY CYCLES 5

    STAT=A2H ADDR=1326H DATA=CDH
    STAT=82H ADDR=1327H DATA=E3H
    STAT=82H ADDR=1328H DATA=01H
    STAT=04H ADDR=FFFFH DATA=13H
    STAT=04H ADDR=FFFEH DATA=29H
(6) *CHANGE DOUBLE REGISTER SP=13FFH
    *BASE HEX
    *EQUATE STOP=1333H
(7) *GO FROM START UNTIL STOP EXECUTED THEN DUMP
    EMULATION BEGUN
    B=01H C=41H D=00H E=00H H=00H L=00H F=56H A=40H P=1320H *=1333H S=13FFH
    EMULATION TERMINATED AT 1333H
(8) *EXIT
    *FFFF
```

Notes

1. Set up user memory and I/O. The program is set up to execute in block 1 (1000H–1FFFH) of user memory, and requires access to the SDK-80 monitor (block 0) and I/O ports in block 0FH. Both ports and memory are defined as available to the user system. All other memory and I/O is initialized by ICE-80 as nonexistent (guarded).
2. A load command generates an error. The type and command numbers indicate that a data mismatch occurred on a write to memory command. The data to be written to address 1320H should have been 06H. When ICE-80 read the data after writing it, a 04H was detected. A change command to a different memory address hints that bit 1 does not go to 1 anywhere in this memory block. Examination indicates that a pin was shorted on the RAM located at 1300H–13FFH in the prototype system. The problem is fixed and a subsequent load succeeds.
3. A real-time emulation is begun. The program is executed from 'START' (1320H) and continues until 'RSLT' is written [in location 1328H, the contents of the accumulator is stored in (written into) 'RSLT'].
4. An error condition results: TYPE 07, CMND 02 indicate the program accessed is a guarded area.
5. The last 5 machine cycles executed are displayed. The last instruction executed was a call (CDH). The fourth and fifth cycles are a push operation (designated by status 04H) to store the program counter before executing the call. The stack pointer was not initialized in the program and is accessing memory location FFFFH.
6. After making a note to initialize the stack pointer in the next assembly, a temporary fix is effected by setting the stack pointer to the top of user available memory.
7. After setting the base for displays to hex and adding the symbol 'STOP' to the symbol table, emulation is started which will terminate when the instruction at 1333H ('STOP') is executed. When emulation terminates, a dump of the contents of user 8080 registers is requested. One can see that the value of the accumulator is set at 40H, the stack pointer is set at 13FFH, the last address executed (*) is 1333H, and the program counter has been set to 1320H.
8. Exit returns control to the MDS monitor.

Figure 3. Sample ICE-80 Debug Session

on the Intellec or user bus by consulting the address map. The processor board allows the ICE-80 CPU to gain access to the bus as a master to "borrow" Intellec facilities. At an emulation break, the processor board stores the status of specified 8080 input and output signals, disables all interaction with the user bus, and commands the trace board to send stored information to a control block in Intellec memory for access during interrogation mode.

Cable Card

The cable card is included for cable driving. It transmits address and data bus information to the user system through a 40-pin connector that plugs into the user system in the socket designed for the 8080 when enabled by the processor module's user bus control logic.

Software

The ICE-80 software driver is a RAM-based program providing easy to use English language commands for defining breakpoints, initiating emulation, and interrogating and altering the user system status recorded during emulation. ICE-80 commands are configured with a broad range of modifiers to provide the user with maximum flexibility in describing the operation to be performed. Listings of emulation commands, interrogation commands, and utility commands are provided in Table 1, Table 2, and Table 3, respectively.

Command	Operation
Base	Establishes mode of display for output data.
Display	Prints contents of memory, 8080 registers, input ports, 8080 flags, 8080 pins, snap data, symbol table, or other diagnostic data on list device. May also be used for base-to-base conversion, or for addition or subtraction in any base.
Change	Alters contents of memory, register, output port, or 8080 flag.
XFORM	Defines memory and I/O status.
Search	Looks through memory range for specified value.

Table 2. ICE-80 Interrogation Commands

Command	Operation
Go	Initiates real-time emulation and allows user to specify breakpoints, data retrieval, and conditions under which emulation should be reinitiated.
Step	Initiates emulation in single or multiple instruction increments. User may specify register dump or tailor diagnostic activity to his needs following each step, and define conditions under which stepping should continue.
Range	Delimits blocks of instructions for which register dump or tailored diagnostics are to occur.
Continue	Resumes real-time emulation.
Call	Emulates user system interrupt.

Table 1. ICE-80 Emulation Commands

Command	Operation
Load	Fetches user symbol table and object code from input device.
Save	Sends user symbol table and object code to output device.
Equate	Enters symbol name and value to user symbol table.
Fill	Fills memory range with specified value.
Move	Moves block of memory data to another area of memory.
Timeout	Enables/disables user CPU ¼ second wait state timeout.
List	Defines list device (diskette-based version only).
Exit	Returns program control to monitor.

Table 3. ICE-80 Utility Commands

SPECIFICATIONS

Paper Tape-Based Operating Environment

Required Hardware

Intellec system
System console
Reader device
Punch device
ICE-80 module

Required Software

System monitor

Diskette-Based Operating Environment

Required Hardware

Intellec system
32K bytes RAM memory
System console
Intellec diskette operating system
ICE-80 module

Required Software

System monitor
ISIS-II

System Clock

Crystal controlled 2.185 MHz ± 0.01%. May be replaced by user clock through jumper selection.

Physical Characteristics

Width — 12.00 in. (30.48 cm)
Height — 6.75 in. (17.15 cm)
Depth — 0.50 in. (1.27 cm)
Weight — 8.00 lb (3.64 kg)

Electrical Characteristics

DC Power Requirements

V_{CC} = +5V, ±5%
I_{CC} = 9.81A max; 6.90A typ
V_{DD} = +12V, ±5%
I_{DD} = 79 mA max; 45 mA typ
V_{BB} = −9V, ±5%
I_{BB} = 1 mA max; 1μA typ

Environmental Characteristics

Operating Temperature — 0°C to 40°C
Operating Humidity — Up to 95% relative humidity without condensation

Equipment Supplied

Printed circuit modules (2)
Interface cables and buffer board
ICE-80 software driver, paper tape version
(ICE-80 software driver, diskette-based version is supplied with diskette operating systems)
Operator's Manual

ORDERING INFORMATION

Part Number	Description
MDS-80-ICE*	8080 CPU in-circuit emulator, cable assembly and interactive software included

*MDS is an ordering code only and is not used as a product name or trademark. MDS® is a registered trademark of Mohawk Data Sciences Corporation.